APPENDIX H: 2012 RESPONSE TO PUBLIC COMMENTS

Presented below are the major issues that capture the substantive concerns raised in the comments received on the Supplement to the Draft Restoration Plan (RP) and Programmatic Environmental Impact Statement (PEIS). The Trustees' responses to the concerns are provided below. Three stakeholders provided comments: EPA region 10, the Port of Seattle, and Vigor Industrial. The EPA assigned the document a Lack of Objection (LO) rating, while the Port of Seattle and Vigor commented on each issue with identical analyses prepared by Windward Environmental. The comments are re-written in italics and the page number and the document source are located at the end of each comment in parentheses. The actual comments are included in the last pages of this document. For references mentioned in the italicized comments, please see the last pages of this document (the actual public comments) for a complete reference citation. Because the EPA supports the proposal, their only comment was a continued suggestion that additional environmental conditions be considered in the analysis to support restoration decisions. The Trustees will follow the guidance of the EPA suggestion as restoration decisions are made.

All of the comments received from the Port of Seattle and Vigor Industrial concern Appendix C and Appendix F of the Supplement to the Draft RP/PEIS. It is important to note that these appendices describe different aspects of the approach used by the Trustees in estimating injury and assigning liability for the purpose of reaching early settlement with those Potentially Responsible Parties (PRPs) interested in settling with the Trustees early to facilitate integration of remedial and restoration actions and/or to avoid having to pay for future assessment costs that non-settling PRPs will share. The Trustees' approach for estimating injury for the purpose of early settlement relies on published scientific literature on the effects of contaminants, data collected by the Trustees and by the various parties who have been doing remedial investigations within the Lower Duwamish River (LDR), and sediment quality standards such as Apparent Effects Thresholds (AETs). It is generally consistent with the approach used successfully at other hazardous waste sites, such as Commencement Bay, Washington, and Lavaca Bay, Texas. There is some uncertainty associated with developing injury estimates using any approach, and the Trustees have been careful to develop a balanced approach in which assumptions used do not predominantly favor either an over- or under-estimate of likely injury. Although the damage assessment is not complete, the Trustees believe they have sufficient information and data available to frame a settlement proposal that would adequately compensate the public for natural resource damages associated with the LDR.

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Appendix C – Defining Injuries to Natural Resources in the Lower Duwamish River

Category A –GENERAL CONCERNS

A1 - Ecological Risk Assessment (ERA) vs. Natural Resource Damage Assessment (NRDA)

In general, we believe that the analysis provided in Appendix C (NOAA and USFWS 2009) is inappropriately based entirely on literature toxicity values and state screening values, ignoring the extensive dataset associated with the Lower Duwamish Waterway (LDW) remedial investigation (RI), including sediment bioassay testing and tissue concentrations, and the assessment of ecological risk in the LDW ecological risk assessment (ERA). (Page 1, Windward Memo)

*In general, the selected values are well below the toxicity reference values used to evaluate these chemicals in the LDW RI; and for PAHs and PCBs, threshold values were established based on biomarkers of exposure that cannot be definitively associated with an effect that would result in a service loss. (*Page 2, Windward Memo*)*

The high hazardous substance concentrations that demonstrably result in meaningful effects on the species present in the Duwamish are simply not found at many locations, resulting in low ecological risk. (Page 3, Port letter)

RESPONSE: The Trustees interpreted the above comments to assert that the Ecological Risk Assessment (ERA) should be used to formulate the natural resource damages. The Trustees determined they cannot base the Natural Resource Damage Assessment (NRDA) on the conclusions of the ERA because the two processes have different programmatic objectives and different statutory and regulatory requirements that result in different data requirements and analytical approaches (Gala et al., 2009). ERAs are not designed to gather data appropriate for a NRDA although, with appropriate coordination, data collected may sometimes be useful to both ERA and NRDA (US EPA, 1992).

For an ERA to serve the needs of a NRDA, the ERA endpoints "need to include natural resource services valued by the natural resource trustees as well as endpoints of concern to the regulators" (Bascietto et al., 1993). One of the major differences between NRDA and ERA approaches is the focus of the assessment effort. ERAs incorporate tests and studies to estimate community or population level effects (US EPA, 1999; Suter et al., 2005; Gala et al., 2009). In contrast, NRDAs commonly include biological responses at the sub-organismal level, such as enzyme induction and physiological changes, and at the organism level (Cacela et al., 2005; Gouguet, 2005; Gala et al., 2009). The U.S. Department of the Interior (DOI) NRDA regulations specifically include a number of suborganism and organism biological responses as injuries (see, for example, 43 CFR §11.62(f)(1)(i)).

Studies have shown that biochemical alterations in response to contaminants can lead to effects such as impaired behavior in predators, leading to population alterations (e.g., Weis et al, 2001). Biochemical and physiological effects are useful in evaluating contamination because of their sensitivity and relationship to populations and communities (e.g., Adams et al., 2000). The ERAs performed for the Lower Duwamish Waterway Superfund site and the East Waterway Operable Unit of the Harbor Island Superfund site specifically excluded biomarker, histological, and behavioral endpoints (LDWG, 2007; Port of Seattle, 2012). The Trustees did use these types of endpoints in estimating injury, as was done in the Commencement Bay NRDA and consistent with the definition of injury in the DOI regulations.

The Commenters suggest that the results of the site-specific toxicity tests should be used in the development of injury thresholds, rather than using AETs to establish such thresholds. The appropriateness of the use of AETs to develop injury thresholds is discussed more specifically in response C1 of this document—Use of AETs for determining injury thresholds. Under the recently revised Washington State Sediment Management Standards (SMS) program, toxicity tests are one method used to delineate and screen areas for future cleanup in addition to other applications. Other criteria are also considered in addition to toxicity tests under SMS. While they are sometimes used to determine injury, toxicity tests are based on short term exposures of a small number of organisms, which limits their applicability. . If site-specific biological data were to be used as part of the Habitat Equivalency Analysis (HEA) process in the LDR, more comprehensive data collection would be needed to identify actual injury thresholds.It is illustrative to show how the results of site specific toxicity testing from an ERA were considered in the NRDA process at Lavaca Bay, Texas. At that site, the ERA included sediment quality triad (SQT) sampling to examine the risk from mercury in the sediments. Those tests did not indicate a significant adverse effect with mercury levels in the sediment from 0.3 to 4.6 mg/kg (a range encompassing both the AET and NOAA Effects-Range Median or ERM values), yet in recognition that sublethal toxicological endpoints were not measured in the SQT approach, the trustees and PRP agreed to use the NOAA ERM value of 0.71 mg/kg as the initial threshold for injury to the benthos and assigned a 10% service loss to that level (Gouguet, 2005). The approach taken by the Trustees in developing injury estimates for the purpose of early settlement is therefore consistent with the approach used in Lavaca Bay in not relying on the results of sediment toxicity tests conducted for the ERA to determine initial thresholds for injury, given that the endpoints utilized do not take into account many potential injuries that could occur.

Another difference between ERA and NRDA that makes using the ERA results in the Lower Duwamish River difficult, is that where ERAs and NRDAs are prospective (related to the future) or current, only NRDAs are also retrospective – evaluating injuries that occurred in the past (Gala et al., 2009). The ERAs conducted in the Duwamish River did not consider past conditions, and were conducted after some dredging and other response actions were undertaken. Therefore, the ERAs are not reflective of conditions that existed in the decades prior to the ERA studies. Even if the ERA had incorporated the Trustees' recommendations concerning endpoints and studies, the results of the ERAs would not quantify the entire injury, because response actions and source control measures have improved conditions in LDR habitats. This means that past injuries would not be accounted for. In their analysis, the Trustees have combined recent sediment contaminant data with older data (when contaminant levels were higher).

The Trustees' approach toward estimating injury in the LDR is based on ecological service reductions provided by contaminated areas of habitat, in this case intertidal and subtidal habitat within the LDR. The Commenter's statement that English sole have expansive home ranges and thus have only a low exposure to contamination is irrelevant to the injury estimation approach used in the LDR that is described in Appendix C. While the Trustees do not agree with Commenters analysis concerning English sole (see comment PAH B1b), the Commenters' assertion ignores the fact that the contaminated areas **themselves** are injured. Specifically, the ecological service of providing clean food is reduced when contaminant levels exceed those that would cause adverse effects to organisms feeding within that area.

The LDR is important in serving as the transition zone for salmonids where they spend time adjusting to higher salinities that they will encounter in the ocean environment, so the services provided by the small amount of remaining habitat in the LDR is critical and has a high value. The importance of small areas of injury is recognized by EPA in its ERA guidance, acknowledging that the "ecological function" can be "more important than its size" (US EPA, 1999). In conclusion, though the Trustees provided input into the development of the ERAs for the LDW and East Waterway investigations, many of these recommendations were not adopted. The decision not to include many of the Trustees' recommendations has severely limited the value of the ERAs for the purpose of estimating natural resource injuries in and proximate to the LDR which, for natural resource purposes includes Harbor Island and Lockheed West Superfund Sites. Unfortunately the ERAs conducted in the LDR do not include consideration of assessment endpoints that reflect ecosystem services, as has been recommended by Munns et al. (2009) to improve the value of ERA data to the NRDA process.

A2 - Data from the EPA Remedial Investigation (RI) and Ecological Risk Assessment (ERA) is not used, haven't incorporated newer datasets

NOAA should…take into account the mountain of new data and information that has been developed for the Duwamish and Harbor Island Waterways since the early-to mid-1990s. (Page 2, Port letter)

In general, we believe that the analysis provided in Appendix C…ignoring the extensive dataset associated with the Lower Duwamish Waterway remedial investigation (RI) (Page 1, Windward Memo)

RESPONSE: The Trustees used all available surface sediment data that meet criteria for use in the Habitat Equivalency Analysis. Only surface sediment data are used, as these represent the biologically active zone that would most directly impact benthic organisms, fish and wildlife. Datasets collected by the Lower Duwamish Waterway Group (LDWG) under the auspices of the EPA Remedial Investigation comprise the bulk of the available data. In addition, any pre-remedial samples that are not located in a dredge footprint (that represent the historical record of contamination in the LDR) are included as they become available and go through a quality assurance process. For a discussion on issues related to use of toxicity test data and the EPA- ERA, please see comment A1.

A3 - Measurement Precision and Service Loss Levels Overlap (e.g. phthalates, dichlorobenzenes)

For many of the chemicals discussed in Appendix C, the AET values that are used to represent different levels of injury are not analytically distinct concentrations. (Page 7, Windward Memo)

RESPONSE: Since the Trustees have chosen at this stage of early settlement to rely on data previously collected under the auspices of the EPA-led Remedial Investigation, we do not control the precision of these data. Unfortunately, for some Substances of Concern (SOCs), detection limits are higher than would be ideal. For non-detect values where the detection limit exceeds the service loss levels, no injury is assigned and the concentration is assumed to be close to zero for purposes of the geographic interpolation. Use of this assumption may result in an underestimation of injury, and illustrates the care taken by Trustees to minimize the likelihood of overestimating injury.

Category B - INJURY THRESHOLDS FOR PAHS, TBT AND PCBS

B1 – PAH Injury Assessment

B1a: Liver disease & injury

The two studies that were cited in Appendix C to support the assessment of injury to fish by PAHs in sediment are Johnson et al. (2002) and Rice et al. (2000). The values selected from these studies to assess injury to fish overpredict injury by assigning injury based on physiological indicators of exposure and reversible suborganismal effects. The data underlying the effects thresholds overestimate the potential for adverse effects. The sediment effects thresholds for liver disease from Johnson et al. 2002 were biased low because all lesion types were assumed to cause disease in affected fish, whereas only a fraction of the lesion types were frank lesions indicative of disease. (Page 2, Windward Memo)

RESPONSE: The Trustees do not agree with the Commenters' conclusion. The federal regulations for NRDAs list seven types of injuries to biological resources that are defined as adverse effects on the organisms and that have been shown to be caused by exposure to hazardous substances: death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction), and physical deformations 43 C.F.R. § 11.62(f)(i). In addition, a biological resource is injured if the concentration of a hazardous substance is present in the edible tissue of the organisms at concentrations that exceed an action or tolerance level established by the U.S. Food and Drug Administration (FDA), or a concentration resulting in a consumption limit or ban issued by a state health agency Id. §11.62(f)(ii),(iii).

Fish are particularly sensitive to PAH toxicity because they metabolize PAHs to toxic and mutagenic intermediates, something that does not occur in invertebrates, or only to a very limited extent (Meador et al., 1995a). Thus fish are susceptible to carcinogenic and mutagenic effects of PAHs, which can occur even at relatively low exposure concentrations (Varanasi et al., 1987). Numerous studies have shown that English sole exhibit biological effects from exposure to PAHs in sediments, including liver cancer and related lesions, reproductive abnormalities, immune dysfunction, and alterations in growth and development (Myers et al., 1994, 1998, 2003; Arkoosh et al., 1996; Johnson et al., 1998).

Physiological indicators of exposure are not the same as liver lesions which equal injury. In fact, all the lesions referred to in the comment are measures of disease, and their presence indicates injury in fish, causing compromised condition that can lead to a reduced ability to survive in the wild. Typically, all pre-neoplastic focal lesions have the potential to progress to neoplasms (tumors), and although not all of them do, it is not correct in the terminology of pathology to call these pre-neoplastic lesions reversible.

Some lesions or other effects may theoretically be reversible (though not neoplasms, or pre-neoplastic focal lesion or foci of cellular alteration) *if the exposure to PAH is eliminated* and the lesions can then heal. The lesion-causing substance or condition MUST be removed to potentially achieve positive outcome. Even if all exposure to harmful levels of PAH stopped—something that will only occur in the LDR after a successful clean up—injury would still take place through reduced fitness, less growth resulting in smaller sized adults and impaired reproduction (Johnson et al., 1988, 1998; Meador et al., 2006; Myers et al., 2008). The Habitat Equivalency Analysis includes a function that accounts for recovery of natural resources once remediation has taken place and the habitat has returned to full function.

B1b: English Sole Ranges

Furthermore, the co-located sediment and tissue data used to develop the hockey stick regression underestimated the PAH concentrations to which English sole were likely *exposed prior to sampling. Stern et al. (2003) conducted a re-analysis of the hockey stick regression using the same lesion data as that used in Johnson et al. (2002) and a larger sediment dataset. Instead of using co-located data from trawls, Stern et al. (2003) used spatially weighted average sediment PAH concentrations from the trawl area collected over realistic home range. This re-analysis resulted in an effects threshold for lesions that is four times higher than that presented in Johnson et al. (2002).* (Page 2-3, Windward Memo)

<u>RESPONSE</u>: The Stern et al. (2003) presentation contains a number of biases. Unlike Johnson et al. (2002), Stern et al. (2003) was not published in a scientific journal that requires a rigorous scientific review process. (The Stern study is part of the Puget Sound Research Conference 2003, Vancouver B.C., proceedings.) The Trustees question several of Stern's assumptions. In the Johnson study, the sediment chemistry was paired with fish samples collected within the trawl track, which were then translated into threshold exposure values linked to certain biological effects such as liver lesions. Sediment samples were collected at the same time or within one year of the fish samples. In this way, the authors determined that fish were present in the area where the sediment samples were measured.

In contrast, Stern's sediment data were not paired directly with the fish samples. Stern used data from a variety of sources and many data points were separated in time by 3 to 4 years. An arbitrarily determined "home range" was defined as 1 km^2, and it was assumed that a sole will use that entire range. However, it is incorrect to assume homogeneity of habitat over a species' entire range. Different types of habitat (preferred and not-preferred) can occur within the larger assumed range.

The Trustees are concerned that the Stern samples are not truly unbiased. The Stern analysis did not account for remediation and restoration actions that were taking place during the time period when the samples were selected, which would have impacted the PAH sediment concentrations. The Johnson et al. scientists also do not believe that several of the areas where Stern chose sediment samples are used by English sole as habitat (Johnson, pers. comm., 2012). Stern assumed that English sole uniformly used the entire area of their defined "home range." Tagging studies conducted on English sole (Moser et al., 2005) in Eagle Harbor provide solid data on English sole movements and suggest that their home range is quite a bit smaller than 1 km^2, and in fact is more in the vicinity of 0.2 km^2.

At Eagle Harbor the tagged fish did not use the shallow nearshore area, which is where the highest PAH concentrations are found. Stern's analysis included these high PAH concentrations in developing thresholds, even though there is no evidence that sole use those areas. Sole migrate into deeper waters at night, but they do not feed at night. During the day they stay within a relatively small area, which could range from 0.2 km^2 – 0.7 km^2 (Moser et al., 2005; Myers, pers. comm., 2012).

B1c: Reproductive Effects- threshold levels and inflection points

The sediment effects thresholds for reproductive dysfunction from Johnson et al. (2002) are highly uncertain. The statistical analysis relied on estimates of the background level of reproductive dysfunction and the inflection point (i.e., the concentration at which effects begin to be elevated above background) because insufficient data were available to calculate these parameters. (Page 3, Windward Memo)

RESPONSE: As shown in Figure C1, threshold levels for service losses are established using a weight of evidence approach based on research with as many different types of organisms and effects from the contaminant of concern as are available. There is an abundance of data on PAH effects to benthic organisms and fish in the Lower Duwamish River. The service loss values and threshold levels for PAH were established using a variety of data showing impacts to fish, including liver lesions, reduced fecundity, and several kinds of reproductive effects. In addition, AETs for echinoderm and Neanthes represent impacts to the benthic community. This weight of evidence of multiple effects from PAH to many ecosystem levels support the service loss levels used in the Habitat Equivalency Analysis.

B1d: Reproductive Effects-Casillas et al. 1991 study

Furthermore, the causal relationship between observed reproductive effects and sediment PAH concentration is unclear. For example, in one study, (Casillas et al. 1991) that underlies the Johnson et al. (2002) relationship for gonadal growth, PAH concentrations accounted only for 34% of the variance in ovarian development, indicating that other factors may be causative. Differences in ovarian development could be due to natural variation in maturation timing among English sole subpopulations in Puget Sound or to exposure to other environmental stressors. (Page 3, Windward Memo)

RESPONSE: It is not clear on what Windward based its 34% assertion for variance in ovarian development in Casillas et al. (1991). However, considering the many possible parameters that could affect gonad development in English Sole, having one parameter (PAH contamination) account for approximately one third of the variance is considered evidence of a highly significant relationship. The authors in Casillas et al. say that natural variability is unlikely to be a major contributor to the effects measured, because of the careful timing of the sampling conducted for the study. Johnson et al. (2002) data indicated that PAH are a major cause of these effects. Another study on the causal relationship between liver neoplasms and other neoplasia-related liver lesions in English sole as related to PAH exposure published in the *Journal of Human and Ecological Risk Assessment* (Myers et al., 2003) corroborated these results with their finding that 54% of the variation in the prevalence of toxicopathic liver lesions in English sole from Puget Sound was explained by PAH concentrations in sediment (Myers et al., 2003).

PAH exposure is identified as a major risk factor for inhibited ovarian development in adult English sole (Johnson et al., 1988). In addition, English sole from areas contaminated with PAH experience inhibited spawning ability and reduced viability of eggs and larvae.

B1e: Creosote / Growth

The sediment effect threshold for growth from Rice et al. (2000) is also uncertain…The major chemical contaminants present at Eagle Harbor were associated with creosote, which is used as a wood preservative. The major creosote-related chemicals generally associated with toxicity are PAHs, phenols, and cresols (ATSDR 2002). About 300 chemicals have been identified in coal tar creosote, but as many as 10,000 other chemicals may also be in this mixture (ATSDR 2002). (Page 3, Windward Memo)

<u>RESPONSE</u>: Sixty-three percent of the creosote from Eagle Harbor is comprised of PAHs, with other components constituting a minor contribution. Therefore, PAHs are likely to be the major contributor to any effects from this creosote.

B1f: Growth Effects

Rice et al. (2000) showed that in one experimental trial, fish exposed to contaminated worms that contained a total PAH concentration of 11.3 parts per million (ppm) dry weight (dw) had a lower daily growth rate than did the controls. In a second trial of the experiment, a similar trend was observed, but the effect was not statistically significant. (Page 3, Windward)

<u>RESPONSE</u>: Rice et al. (2000) found a severe impact to growth at a total PAH concentration of 11.3 ppm dry weight in prey (polychaete worms) fed to English sole. This would equal a prey whole-body concentration of approximately 2.2 ppm wet weight. The total PAH concentration in the test sediments for prey exposure were 3.1 and 3.6 ppm dry wt. Rice et al. (2000) conducted two experiments with very similar results producing severe growth impairment. One experiment was highly significant and the other was not, even though the mean percent change in fish weight was 24 times lower (1.2% per day increase for the control versus 0.05% per day for the treatment) for the non-significant test. Because the first test was highly significant and the second test supported those results, these data strongly implicate total PAHs as a growth inhibitor. As the authors (Rice et al., 2000) admit, these tests had low statistical power, making these results even more striking. There is no doubt that if the power was higher, the second test would have also been statistically significant. Even though this study was conducted with field contaminated sediment, it was diluted with clean sediment, producing a concentration that was only 0.1% of the fully contaminated sediment. The predominant

contaminants at Eagle Harbor are PAHs and the main source is creosote. The only other contaminants of note at Eagle Harbor are elevated PCBs (up to 2.5 ppm dry wt. in sediment) (Misitano et al., 1994). For the diluted sediment of 0.1% (used in Rice et al., 2000), the concentration of PCBs in the polychaetes would be extremely low due to an equivalent test sediment concentration of only 2.5 ppb. The expected PCB concentration in these worms would have likely been in the 10–20 ppb range, which is far below any toxic threshold for this class of toxicants.

B1g: Evaluating PAH impacts to sole

The exposure of highly motile organisms such as English sole is integrated over the entirety of their home range and cannot be evaluated on a point basis. (Page 4, Windward Memo)

<u>RESPONSE</u>: The comment misses the point that, as explained in A1, the Trustees are basing their approach to estimating injury on the reduction in ecological services provided by the habitat. In addition, areas of sediment with contaminant concentrations above those that could cause injury to organisms feeding within those areas are themselves injured. Moreover, contrary to the Commenters' assertion, it *is* possible to directly measure PAH exposure in fish. This can be done with metabolites from fish bile, which have been shown to be strongly correlated with sediment PAH values and dietary dose (Collier et al., 1993, as seen in Meador et al., 1995b; Meador et al., 2008). Also see comment B1b which discusses issues related to English sole home range size and feeding habits.

B2 – TBT Injury Assessment

B2a: Use of Armandia Brevis

The development of TBT injury threshold values is based on work that evaluated the effect of TBT on the marine polychaete <u>Armandia brevis</u> (Meador and Rice, 2001) and bioaccumulation modeling based on relatively few datasets, including the <u>A. brevis</u> data (Meador et al., 2002). There is a significant amount of literature on the effects of TBT on benthic organisms that is not represented. The bioaccumulation potential for TBT has been shown to be highly species specific (Meador et al., 1997). Further justification should be provided to support setting injury thresholds based on a polychaete species that has not been observed in the Lower Duwamish River. (Page 4, Windward Memo)

<u>RESPONSE</u>: Meador (2011) summarized information from several studies on the occurrence of organotins in the tissues of fish and invertebrates and their toxicological significance. The information from nine studies dealt with a variety of adverse effects from TBT exposure (e.g., behavior, imposex, growth impairment, reproductive impairment, and mortality) and listed five mean critical body residues with values between 13 and 85 ppb. Regarding the statement questioning the appropriateness of using

A. brevis data for the injury threshold analysis, that species is a commonly occurring marine polychaete in Puget Sound. Schoch and Dethier (2001) indicated *A. brevis* was encountered at over 80% of stations sampled within six miles of the mouth of the Duwamish River during their intertidal surveys in 1999 and 2000. This information strongly suggests that *A. brevis* is a very appropriate candidate for injury assessment. If *A. brevis* is not currently present in the LDR, it could very well be because contamination levels in the river sediment prevent them from surviving there.

B2b: TBT and EPA Ecological Risk Assessment (ERA)

TBT was not identified as a risk driver in the ERA conducted for the LDW Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) evaluation based on the evaluation of imposex in benthic organisms collected throughout the site and the evaluation of chemical concentrations in tissue collected from throughout the site and compared with tissue effect concentrations. The data collected from the site is not consistent with the level of injury that would be predicted by the proposed injury threshold values. (Page 4, Windward Memo)

<u>RESPONSE</u>: See comment A1 clarifying the differences between the objectives for ERA and NRDA. While TBT was not identified as a risk driver in the LDW ERA, it *was* included as a risk driver in the East Waterway ERA, based on recommendations and rationale presented by NOAA.

Meador et al. (2002b) concluded that protection against severe adverse sublethal effects for many salmonid prey species should be achieved with a TBT sediment concentration of 6,000 ng/g OC (organic carbon). For the Lower Duwamish River (average TOC = 1.7%) this would equal 102 ng/g dry wt. The Trustees assigned the lowest injury (service loss) level (5%) to this concentration. However, it should be noted that Meador (2002b) further mentioned that many of the sublethal responses reported for TBT exposure would eventually lead to death of the organism in the environment. A later publication (Meador, 2011) listed several additional studies of fish species with low threshold levels that would further diminish the Duwamish TBT threshold, should the Trustees re-evaluate TBT injury thresholds utilizing these new studies. Based on these new studies, the current TBT injury thresholds used by the Trustees cannot reasonably be said to overestimate injury.

B3 – PCB Injury Assessment

B3a: Estimated parameters in Meador 2002a

The relationships between sediment concentrations and adverse effects reported in Meador et al. (2002) rely on several assumptions that are highly uncertain. Meador et al. (2002) estimated organic carbon-normalized sediment effect thresholds from lipid-normalized PCB concentrations in salmon that were associated with various effects. In each of the 15 studies underlying this relationship, some data critical to the analysis (e.g., *tissue PCB concentrations, tissue lipid concentrations) were not reported but were instead estimated based on uncertain assumptions…* (Page 4, Windward Memo)

RESPONSE: Meador et al. (2002a) did not use uncertain assumptions. Meador reviewed numerous studies on PCB effects to salmonids. From the larger pool of published studies, 15 were selected using rigorous screening criteria (Meador et al., 2002a). These 15 studies used different methodologies and measured different types of PCB effects, therefore it was necessary to standardize the results based on appropriate scientific methodology. Because PCB effects on individual fish are greatly affected by the lipid content of the fish, Meador developed lipid values to lipid normalize the results. The lipid values used in Meador et al. (2002a) were taken from literature studies that actually measured (not estimated) lipid levels. Meador et al. (2002, Table 1) shows the extensive dataset used to develop the lipid values incorporated into the PCB threshold values. Data from 18 different studies including adult and juvenile fish were examined with sample sizes ranging from 3 to 180 individual fish.

B3b: Tissue residue concentrations

Based on these assumptions, Meador et al. (2002) calculated a PCB tissue residue of 1.7 ug/g lipid as the effect threshold. A later report… by (Melancon et al. 1989) suggested that such effects occur at a muscle concentration of approximately 0.3 ug/g wet weight (ww) which, using the assumptions from Meador et al. (2002) would correspond to 3.3 ug/g lipid. Similar assumptions made for the other 14 studies are more likely to underestimate rather than overestimate the tissue concentration at which the effect is likely to occur. Consequently, the sediment effects thresholds are more likely to underestimate than overestimate realistic effect thresholds and result in an overprediction of injury. (Page 5, Windward Memo)

RESPONSE: The sediment effect thresholds do not underestimate realistic effect thresholds and do not result in over-prediction of injury. Meador et al. (2002) used a Melancon study (Melancon et al., 1989) which suggested an effects level of 1.7 ug/g lipid. The overall effect threshold recommended by Meador for all the studies considered is 2.4 ug/g lipid. For PCBs, muscle concentrations are usually lower than whole body concentrations. Using measurements in muscle ignores the PCBs in the rest of the fish. Additionally, lipid concentrations in muscle are not comparable to whole-body lipid levels and should not be used interchangeably, as assumed here by Windward when they converted the wet weight concentration in muscle to a lipid normalized value. Meador et al. (2002) cites a number of studies that demonstrate how PCB levels in fish differ between muscle and other organs, and how PCB levels will re-distribute themselves within the fish depending on its life stage, energy content, and availability of food.

B3c: Physiological indicators of exposure

> *…many of the effects included in Meador et al. (2002) are physiological indicators of exposure and reversible suborganismal effects. Examples included altered levels of hormones, changes in enzyme activity, or decreases in the synthesis of vitellogenin. The effects associated with a 60% service loss from NOAA (2001) are also biomarkers (i.e. immune suppression and cytochrome P450 induction). The consequences of such alterations in biochemical processes with regard to the health of the fish are largely unknown.* (Page 5, Windward Memo)

RESPONSE: The statement that consequences of alterations in biochemical processes on fish health are unknown is misinformed. This is another reiteration of the commenters' assertion that a reversible or sublethal effect does not cause injury, which is simply untrue. The commenters assert that altered hormone levels, increased enzyme activity, and disease susceptibility are not 'injuries.' Individual salmon must undergo complex physiological processes that allow them to make the transition from freshwater to the marine environment. Throughout the transition, they need to be able to resist disease, mature normally and successfully complete their lifecycle (Meador et al., 2002). Thus, the physiological indicators noted in Meador et al. (2002) and NOAA (2001) indicate alteration in the biochemical processes that negatively impact salmon. These sublethal impacts caused by PCBs adversely impact these processes by reducing the fitness of the salmon. Impairment of vital functions may also affect a fishes' ability to tolerate normal environmental fluctuations, including smoltification. These impacts are discussed in more detail in Meador et al. (2002).

Even if the studies showing P450 induction were removed from the list of studies supporting the service losses for PCBs, the result would not change. Immune suppression and reduction in growth are both well-defined indicators of injury (Meador, pers. comm., 2012). Furthermore, vitellogenin is a precursor for many yolk proteins necessary to provide nutrients during early development of vertebrates, and so a reduction in vitellogenin production would be expected to impact reproductive success.

Published studies using disease challenge have shown the effects of immune suppression, which leads to death of fish.

Category C – USE OF AETS IN INJURY ASSESSMENT

C1 - Use of AETs for determining injury thresholds

> *"For chemicals other than PCBs, PAHs, and TBT, apparent effects thresholds (AET) values are used to calculate service losses. This use of AETs is not consistent with their intended use as screening values that most accurately identify sediment for which no*

biological effects would be expected. The exceedance of an AET may or may not indicate the presence of biological effects." (Page 2, Windward Memo)

AET values were developed as screening concentrations and are inherently conservative values that will overestimate biological effects. (Page 5, Windward Memo)

The sediment used in the development of AETs contained a variety of chemicals with a range of concentrations. (Page 6, Windward Memo)

AETs are inherently conservative values and are most useful as screening benchmarks. There is no basis for using AET values as the threshold concentrations at which a particular hazardous substance causes damage to natural resources because AETs do not establish a causal relationship between biological effects and a chemical of concern. (Page 5, Windward Memo)

RESPONSE: Sediment quality guidelines such as AETs, are frequently used as thresholds for injury in settlements of natural resource damages across the country. Using sediment quality guidelines by the Trustees for the purpose of developing estimates of injury for settlement in the LDR is built on this established practice. Though the commenters suggest that AETs *over*estimate biological effects, AETs may actually *under*estimate injury because they incorporate effects only on benthic invertebrates and then measure very few potential adverse effects to those organisms (such as mortality).. Neither do AETs take into consideration effects of contaminants on fish or bioaccumulative effects in higher trophic levels.

The approach used by Trustees in the LDR uses AETs to establish the initial threshold for injury for most contaminants. A recent paper discussing the use of Sediment Quality Guidelines in NRDAs recommends that a "reasonably conservative threshold" near the Lowest Observed Adverse Effects Level (LOAEL) should be used for the "onset of injury" and "less conservative" sediment quality guidelines, such as AETs, be used to represent an increased level of severity of injury in damage assessments (Gouguet, 2005). This was how an AET was used in the NRDA at the Lavaca Bay, Texas Superfund Site.[1] The use of AETs to set the initial threshold for injury by the Trustees in the LDR is therefore less conservative than this recommendation, and not likely to overestimate injury.

[1] ***The approach taken in the LDR NRDA may underestimate injury compared to the approach used in Lavaca Bay since the benthic AET for mercury of 2.1 mg/kg was used there as recommended in Gouguet (2005) as an indicator of an increased level of severity of injury, and was assigned a 25% service loss, whereas the approach used by trustees in the LDR uses AETs as the initial threshold for injury for most contaminants and assigns only a 5% service loss. Additionally, injury to fish due to mercury contamination of habitats was evaluated separately and added to the injury from contamination of habitat to benthic organisms in Lavaca Bay (Trustees, 2000), resulting in much higher service loss estimates than would have been developed using the approach utilized by Trustees in the LDR with the same data.***

The Trustees recognize that AETs were developed from field data which contained a variety of different chemicals. This reflects the actual situation in the LDR, which also contains a mixture of contaminants. This approach takes into account the synergistic effects of mixtures that commonly exist in Puget Sound sediments that influenced results of the toxicity tests used to derive AETs.

The Trustees' methodology for estimating injury for purposes of early settlement is based solely on ecological losses and does not attempt to quantify or recover human use losses and other economic damages; therefore, it cannot be reasonably viewed as overstating the extent of the damages resulting from releases of hazardous substances to the LDR. Rather, the Trustees may be understating their natural resource damage claim. Human use losses and other economic damages may be evaluated for inclusion in any damage assessment process moving forward for those non-settling parties along with further assessment of ecological damages that may be necessary to support all natural resource injuries.

C2 – Injury Ramps

… the "injury ramp" for butyl benzyl phthalate (BBP) is presented in Table 1. No effort was made to evaluate the available sediment bioassay data for the Lower Duwamish River to determine the relevance of the AET thresholds for the mixture of contaminants at these sites. Increasing levels of injury are assigned based on the exceedance of multiple AET values. No justification is provided for increasing service loss percentages when multiple AET values are exceeded. (Page 5, Windward Memo)

RESPONSE: Justification is provided for increasing service loss percentages when multiple AET values are exceeded in Appendix C, which provides a detailed explanation of how different levels of service loss were estimated. The basic approach advocated by Gouguet (2005) is utilized: higher levels of service loss are assumed as the number of sediment quality guidelines exceeded increases. For most SOCs, there is insufficient information to establish sediment thresholds that are protective of fish. Therefore, the only injury thresholds used are those to protect the benthic community, largely AETs. For all of these chemicals, the minimum injury threshold is 5%, and the maximum is 20%--based solely on effects to invertebrates. Appendix C includes a detailed discussion of why assigning only a 20% loss of service when all invertebrate AETs are exceeded can be criticized as being too low, using HCB as an example. These chemicals may actually affect fish and other higher trophic levels as well, and most likely a higher service loss would be applied if the data were sufficient to make these determinations. On the other hand, for PAHs, there are known effects on fish as well as on benthic organisms. Therefore, a higher service level loss is applied. Although PAHs are metabolized by fish, it is during this very process that harmful effects occur. Since this HEA is directly oriented toward protection of living marine resources (versus human uses), known effects on fish at the minimum injury threshold, as well as known effects on benthic organisms, justifies a higher service loss than SOCs for which there are only known benthic effects. It is the difference in the available data regarding the effects of contaminants, rather than a subjective view of a contaminant's importance, that leads to the difference in assignment of service level losses.

C3 - Case Study: Evaluation of Effects Predicted by AETs Compared with Effects Measured in Lower Duwamish Waterway (LDW) and East Waterway (EW) Sediment

In order to evaluate the predictive power of AETs in the Lower Duwamish River, a dataset of 101 sediment samples collected from the LDW and East Waterway (EW) of Harbor Island was evaluated…The reliability of the chemical concentrations above the AETs as indicators of biological effects, as measured by the sediment bioassays, was evaluated…However, for the 95 samples that exceeded at least one of the AET values, the exceedance of the AET did not necessarily accurately predict the biological effects associated with the bioassay results. In 54% of these samples, the chemical exceedence of the AET was consistent with a bioassay result, which also exceeded the SQS threshold. However, in 46% of the samples, no toxicity was observed in the three sediment bioassay results for a sample. (Page 10-11). *These results suggest that the exceedance of an AET value should not be used as a reliable indicator of certain biological effects. AETs may function well as screening levels, but they are clearly not a reliable indicator of biological effect as demonstrated by the LDW and EW sediment bioassay results.* (Page 7, Windward Memo)

Finally, the LDW data was examined to determine whether the exceedance of multiple AETs increased the predictive power of the AET evaluation….This analysis would suggest that predictive power of the AETs is not improved when multiple AET exceedances are present. (Page 7, Windward Memo)

RESPONSE: The commenters assert that the Trustees' assessment is flawed because it relies on AETs and does not consider the results of toxicity tests performed as part of the ERAs for the Lower Duwamish Waterway (LDW) superfund site and the East Waterway Operable Unit of the Harbor Island Superfund site. As discussed in section A1, ERA for remedial purposes and NRDA are structured to address very different objectives. The toxicity tests performed as part of the ERA were intended to help inform what remedial actions should be performed, and did not include important sublethal endpoints that would be important in determining injury. Furthermore, the results of the analyses conducted by Windward are biased by the way samples were chosen for toxicity testing for the ERA. The ERA toxicity tests from the LDW intentionally excluded samples that were highly contaminated, under the assumption that these samples would be toxic (LDWG, 2007). If this assumption is true, (i.e. that the excluded samples are toxic), then the reliability of AETs to predict adverse biological effects in the LDW would be far greater than is suggested in the comment. Despite this, for more than half of the 95 samples included in the commenters' analysis, the chemical exceedance of the AET was consistent with the bioassay result. This is also true of the Windward analysis of multiple AET exceedances, which suffers from the same bias in the selection of samples- over 50% of the samples matched the predictions.

An independent evaluation of the ability of AETs to predict adverse biological effects using data from 13 Puget Sound embayments indicated that adverse effects were not found for samples with contaminant concentrations below the AET but were found for samples exceeding the AET in over 85% of the samples (Barrick et al., 1988). This means that approximately 85% of samples were in accordance with the predictions. A more recent evaluation of AETs found that reliability of the AETs in predicting adverse effects was 84% (Gries and Waldow, 1996). The results of these two studies, using unbiased samples, support the reliability of AETs in Puget Sound as predictors of adverse effects. Given that the AETs are based only on a few potential endpoints with a few receptors, ignoring other receptors and other endpoints indicative of other potential types of injuries, the use of AETs in the Trustees' injury estimation approach is very unlikely to result in an *over*estimate of the ecological injuries.

Appendix F - Allocation Process in the Lower Duwamish River Natural Resource Damage Assessment

Category D – TEXT IS TOO GENERAL, NOT SITE-SPECIFIC, AND ALLOCATION IS ARBITRARY

D1 - General allocation - liability allocation methodology is arbitrary

…arbitrary allocation methodology…certain public and private entities are unjustifiably assigned vast amounts of natural resource damages liability, with other parties that have been responsible for significant releases apparently being assigned little or no such liability. (Page 1, Port cover letter)

RESPONSE: This is a vague and conclusory statement for which the Port does not provide any documentation or other evidence. Moreover, the allocated liability for each potentially responsible party is not publicly available as such discussions are legally protected as settlement negotiations pursuant to the Federal Rules of Evidence; therefore, it is unclear as to how the Port reached this conclusion. The Trustees disagree with the Port's assertion. This is not an arbitrary allocation methodology and no entities were unjustifiably assigned vast amounts of natural resource damages liability. Allocations of liability for the purposes of early settlement are based on publicly available records and follow the specific parameters outlined in Table F1 in Appendix F. To the extent the Port has any additional information that the Trustees have not considered relating to significant releases by other PRPs, the Trustees will review and consider such information. In the event a PRP resolves their liability through a settlement, the Trustees must show the court a fair and equitable basis as to the liability and resolution of any PRP's liability. An existing example is the Boeing Consent Decree.

D2 - Allocation does not take advantage of available information

In general, the process provided here is overly simplistic and does not take advantage of the extensive chemistry dataset and current and historical source control documentation that is available for use in the allocation model. (Page 2, Windward Memo App. F)

RESPONSE: Trustees considered all of the sediment chemistry and current and historical source control information available to them at the time the allocation was done. When the process was first undertaken in 2001, source control information in the LDR was limited, and incomplete for some areas. As the Washington Department of Ecology and US EPA have completed additional source control studies for properties along the LDR, the Trustees continue to incorporate this data into the allocation at regular intervals. For example, in 2011, the Trustees updated the allocation of PAH liability and revised the analysis using current scientific research and new data.

D3 - Allocation of overlapping contaminant footprints

In cases where a plume that originates at one parcel overlaps onto adjacent parcels, liability has been allocated to multiple parcels rather than to the single parcel that is the likely source. In cases where sufficient information is available to identify the unique sources, the Trustees should allocate liability to the specific source rather than simply allocating liability to all adjacent properties. (Page 2, Windward Memo, App. F)

RESPONSE: The Trustees allocate liability to the specific source to the extent there is evidence that the use of a SOC could be associated with an activity on that property, and a pathway is established. Specifically, when an injury footprint for an individual SOC touches more than one property, each property is examined for a possible connection to that contaminant. Allocations of liability for the purposes of early settlement are based on publicly available records and follow the specific parameters outlined in Table F1 in Appendix F.

For all parcels where the criteria noted in Table F1are answered in the affirmative, liability is assigned for the SOC in question. In some instances, a large footprint is shared among several parcels, and in other cases, a single parcel will receive the full allocation for the footprint, depending on the results of the decision tree in F1. If the Port or other parties have access to information not in the public domain that they feel would contribute to the allocation decision process, and are willing to share such information with the Trustees, the Trustees would include any viable evidence in the allocation process.

D4 - Unfair to Allocate Only to Current Property Owners

…the approach to liability allocation used by NOAA, as described in Appendix F, that results in current shoreline property owners being assigned essentially all site NRD liability, including liability for activities that occurred in the distant past that current shoreline property owners had no role in, and liability for hazardous substance releases that clearly originated from other parties. (Page 1, Port Cover Letter)

RESPONSE: Each person's allocated liability is attributable to publicly available information showing releases of hazardous substances from each identified property. In general, current owners are strictly liable for any on-going releases from their property and as such are liable for such releases. To the extent that any current owner is able to bring evidence that another person is responsible for specific contamination on their property and which contributed to injury to the natural resources in the LDR, the Trustees remain open to allocate such liability, in whole or in part, to the prior owners and/or operators. As noted above, in the event a PRP resolves their liability through a settlement, the Trustees must show the court a fair and equitable basis as to the liability and resolution of any PRP's liability.

Category E – DOCUMENT DOES NOT CONSIDER SOURCES WITHIN THE PIPESHED

E1 – Allocation of Pipeshed Sources

The approach does not adequately consider sources within the pipeshed for storm or combined overflows; …characterization of the chemical loads used for this purpose was not provided. (Page 2, Windward Memo, App. F)

RESPONSE: The allocation methodology does consider the sources within the pipeshed for both storm drains and combined overflows. Trustees accounted for contaminant inputs to the river via combined sewer outflows (CSO) and storm drains using the same methodology used to assign liability to properties. If a contaminant footprint was closely associated with an outfall, if available data showed a contaminant was known to occur in storm drains or CSOs, and if there was no other source of that contaminant on adjacent properties, then the footprint liability was assigned to the CSO or storm drain. The basins that drain into each CSO or public storm drain are large, covering hundreds of acres and properties. It is unlikely that quantification of these large basins and storm drains is readily available or likely to be obtained at a reasonable cost.

E2 - Allocation doesn't include parcels that are not adjacent to the LDR

The document fails to address parcels that do not abut the Lower Duwamish River but are associated with current and historical activities that may have resulted in the release of contaminants in to the Lower Duwamish River (Page 1, Windward Memo App. F)

RESPONSE: Trustees included all properties within the designated area of the NRDA that are adjacent to the LDR as well as those that have a documented connection to the LDR (See page F-1). Initially, 458 parcels were reviewed. In addition, storm drains and CSOs that drain large areas beyond the river were included in the allocation.

If the Commenters have knowledge of and can document other sources that have contributed contaminants to the LDR, the Trustees request that the Commenters submit such for review and analysis.

Category F – PAH ALLOCATION ISSUES

F1 - Mass balance approach for PAHs is incomplete, concerns related to creosote pilings

The mass balance approach used for polycyclic aromatic hydrocarbons (PAHs) is not fully explained in this document. The information that has been provided on the calculation of PAH release rates for marine pilings suggests that the release of PAH from creosoted marine pilings has been greatly overestimated. (Page 1, Windward Memo, App. F)

RESPONSE: The Trustees do not agree that releases of PAH from creosoted marine pilings has been greatly overestimated. Estimates of PAH releases from creosote-treated marine pilings were derived using information published in a 2007 study of PAH sources to the New York/New Jersey Harbor (Valle, 2007) and a 2011 report by the Washington Department of Ecology (ECY) regarding sources of contamination to the Puget Sound basin (ECY 2011).

Using the size of pilings removed as reported in the Washington Department of Transportations' (WSDOT) Creosote Removal Initiative for state ferry terminals and PAH leaching rates as reported by Valle, ECY reported that 0.062 Kg of PAH per pile per year is released to the air and 0.48 Kg PAH/pile/year is released to the water. As shown in Figure F1, it was assumed that 10% of the pile was exposed to air, 60% to water, and 30% to the sediments. Since ECY only reported values for air and water, it was assumed that the 0.48 Kg PAH/pile/year included both the portion of the piling exposed to the water column and the portion embedded in the sediment.

The assumption was made that pilings used in the LDR would be of lesser length and smaller diameter than those used by the ferry system, so only 75% of the 0.48 Kg PAH/pile/year value was used to represent the release from smaller pilings. This result (0.36 Kg PAH/pile/year) was then multiplied by 0.3 to represent the 30% of the piling exposed to the sediment (0.11 Kg PAH/piling/year), and then by 0.2 (on-site diminution factor) which results in the assumption that only 6% of the area of the piling is contributing PAH to the sediments biologically active zone (0.022 kg PAH/piling/year). Although there is evidence in the literature that some portion of the PAH released to the air and water does contribute to the PAH levels in the sediment, these releases were not included in the NRDA PAH assessment. Other creosote-treated elements associated with the pilings (cross-beams, ties, planking, etc.) were also not included, although PAH contribution would also be expected from both releases to the air and from rainwater leaching. These exclusions provide a buffer that compensates for potential differences in the leaching rate (reported by Valle and ECY) when salinity, temperature, flow rate, and other factors specific to conditions in the LDR are considered.

As shown in Figure F1, two different Diminution Factors were applied to the 0.11 Kg PAH/pile/year value. First, an on-site factor of 0.2 was applied. The on-site Diminution Factor addresses the portion of the PAH that was likely to impact the biologically active zone. The following mechanisms for migration to the biologically active zone were considered: direct leaching from the pile and spreading caused by scour; direct leaching to the sediments within the zone of disturbance caused by ship operations (this zone was assumed to be up to two feet thick at the face of the piers with a lesser thickness below the piers); convective migrations in the pore water; migration in preferred seepage paths along the piles caused, in part, by pile movement; and loss of treated wood resulting from ship impact and pile aging.

Next, the in-river Diminution Factor of 0.5 was applied. This is based on the assumption that approximately half of the PAH released to the sediment would remain in the same general area after being adsorbed or absorbed.

The product of the two Diminution Factors is 0.1. Essentially, after application the two Diminution Factors, only 10% of the 0.11 Kg PAH/pile/year was included when impacts to the waterway sediments were quantified: a final value of 0.011 Kg PAH/pile/year.

Google maps and United States Army Corps of Engineers Report No. 36 (USACE 2002) were then used to determine the size of pile-supported structures such as docks, causeways, dolphins, etc. Where dock dimension data were incomplete, the length was assumed to be 71% of the property length (the average for known sites) and the width perpendicular to the waterway was assumed to be 60 feet. A 10-foot pile spacing was assumed based on the USACE guidelines.

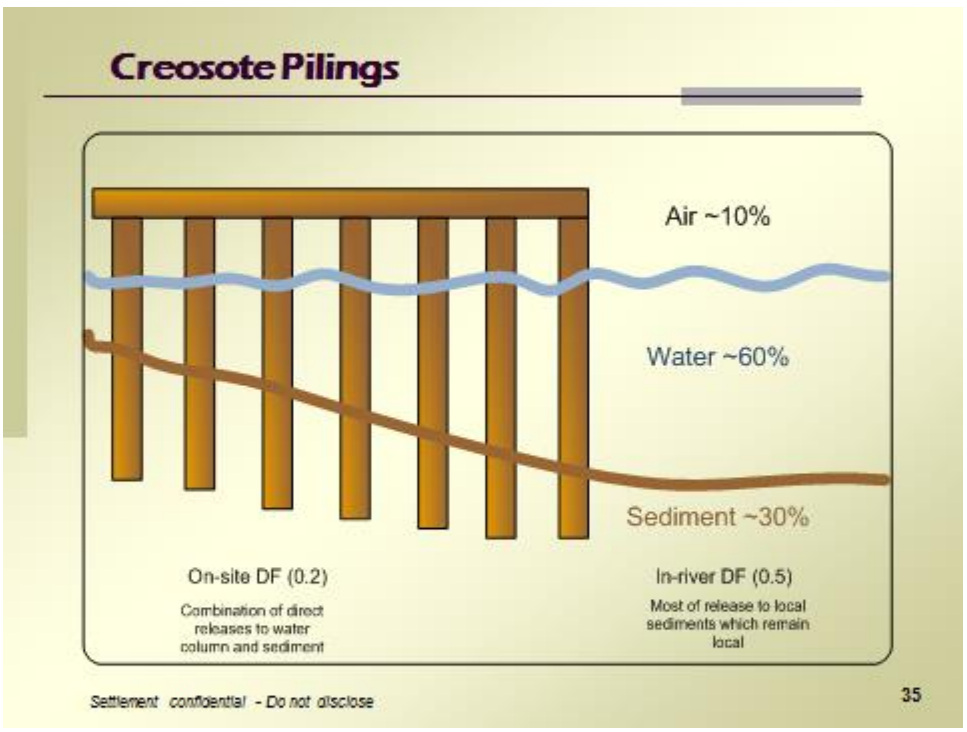

Figure F1. Schematic showing how creosote pilings were treated in the PAH NRDA analysis.

F2- Release rates for creosote pilings are overestimated; concerns about the leaching rate from the Valle and Ecology reports; effects of temperature and salinity

The desorption rate is based on freshwater exposure…has been shown to be strongly temperature dependent… (Page 3, Windward Memo, App. F)

The leaching rate of PAHs was observed only at the surface (1mm) of the treated piling…therefore, only a small volume of creosote is available to function as a source of PAHs due to leaching. (Page 3, Windward Memo, App. F)

PAH desorption rates decline exponentially following the placement of freshly treated wood. (Page 3-4, Windward Memo, App. F)

…the rate of PAH release derived by Valle et al. (2007) is an overestimation of the release of PAHs from the pilings into the water column in Puget Sound waters… (Page 4, Windward Memo, App. F)

RESPONSE: Both Valle et al. (2007) and Washington Department of Ecology (2011) agree that there is a level of uncertainty associated with the leaching rate. In Valle et al. 2007, leaching rates from two reports (Ingram et al., 1982; Bestari et al., 1998) were reviewed and used to calculate leach rates using four different methods (Valle, Table 3.5). The authors selected the average value (23% loss of PAH over 30 years) as the leach rate for the New York/New Jersey harbor. This same rate was used in the Ecology report and the NRDA PAH analysis.

A number of authors have attempted to produce a model which quantifies the PAH leach rates from a creosote-treated pilings. In a 2006 report prepared by Stratus Consulting and Duke University *2006*), the leaching models from twelve different researchers were reviewed to determine the relative strengths and weaknesses of each approach. The Stratus report did not identify any leach rate model as a preferred or definitive approach.

For the NRDA PAH analysis, it was necessary to estimate the amount of PAH in the waterway sediments that originated from creosote-treated pilings. Due to the differences in the leach rate models discussed in the literature and the uncertainty about the inputs to the models, the relatively straight-forward model proposed in Valle et al. 2007 (and also used in ECY 2011) was used as the leaching rate.

The assumption that the leach rate continues to decrease with time has been contradicted in the literature. For example, a more recent report by Kang et al. (2005) shows that after about a week at a very high leach rate, the leach rate reached a lower steady state. Also, as pilings age, other factors such as crumbling and abrasions (from ship traffic, debris, etc.) would expose fresh creosote that would leach at a rate closer to the much higher initial rate.

It is understood that this analysis is based on data generated from warmer and less saline waters, and if the analysis was re-run using conditions similar to those found in the Duwamish waterway, a lower value might be calculated. Other studies show that leaching rates increase with increased water velocity. However, since our analysis uses diminution factors that reduce the amount of PAH so that only 3% of the estimated PAH leached is considered to have contributed to sediment contamination, we believe our approach compensates for uncertainty in the leaching rates.

Additional assumptions in the PAH loading estimate from creosote pilings:

- No contribution from the portion exposed to the water column is included. Using the ECY example and applying the same factors as were used for the portion exposed to the sediment, an additional 0.022 Kg PAH/pile/year would be allotted for the portion exposed to the water.

- No contribution from the portion exposed to the air is included, although some research indicates that when creosote-treated wood is warmed by sunlight, micro-droplets of creosote are exuded from the wood, fall into the water and directly impact the sediments (Goyette and Brooks, 1998). Using the ECY example and applying the same factors, an additional 0.005 Kg PAH/pile/year would be allotted for the portion exposed to the air.

- No contribution was included from other materials such as cross-ties, planking, etc., which would leach PAH into the water from both rainfall and from micro-droplets.

- It was assumed that pilings only leach for 30 years, even though pilings often remain in the water for up to 70-90 years and continue to leach during that time frame.

In summary, there is some uncertainty in creosote leach rates and these may be influenced by site-specific factors such as temperature, salinity, velocity and age and condition of the pilings. The leach rate calculated here is based on the available scientific literature and is applied to the loading estimate with diminution factors so that only 3% of the PAH estimated to leach from a piling over 30 years is considered to contribute to PAH sediment contamination. The use of diminution factors accounts for uncertainty in the leach rates and provides a conservative estimate of creosote pilings contribution to PAH in sediments.

F3- Inappropriateness of relating PAHs with sandblast grit

"The association of PAHs with sandblast grit is inaccurate and results in an inappropriate assignment of discounted service acre years (dSAYs) to non-contributing parcels." (Page 1, Appendix F)

"…the rationale for associating PAHs with sandblast grit is not known." (Page 6, Appendix F)

"Metals and tributyltin are the primary chemicals associated with sandblast (also known as abrasive grit blast [AGB])…For the …CERCLA sediment remediation project implemented at Todd Pacific Shipyards…constituents of AGB were analyzed, and a definition of AGB in sediment was prepared and approved by the US …EPA…Copper, arsenic, and zinc, as well as grain size, were considered diagnostic of AGB, not PAHs." (Page 6, Appendix F)

"PAHs are not constituents present in sandblast grit, and the manufacturers do not analyze for PAHs. Based on the above information, the correlation between sandblast grit and PAHs is inaccurate and should be removed." (Page 6, Appendix F)

<u>RESPONSE</u>: The Commenter contends that metals (copper, arsenic, and zinc) and TBT are the primary chemicals associated with sandblast grit, which they refer to as abrasive grit blast. The USEPA definition referred to in the comment is published in USEPA (2003), related to the sediment remedial action at Todd Shipyards. The purpose of the definition was to provide guidelines to determine whether abrasive grit blast was present, and not to state what may be present in *spent (used)* abrasive grit blast. Specifically, the definition states that abrasive grit blast is present if it is visually identified, *or* if copper, arsenic, or zinc is present above certain concentrations and the material is coarse (0.15 – 2.0 mm in size).

The purpose of this definition was solely to identify abrasive grit blast that needed to be removed as part of the remedial action, which was to lower the levels of lead. The EPA states "the abrasive grit blast definition is a generic definition developed solely for the TSSOU" (operable unit at Todd Shipyards).

The Commenter also contends that there is no correlation between sandblast grit and PAH, based on a review of the constituents of grit from three different manufacturers (Kleen Blast, Tuf-Kut, and Green Diamond). The Trustees agree that it is unlikely that PAH would be present in clean (unused) sandblast grit when the product is received from the manufacturer. *Used* sandblast grit, however, will contain elevated levels of contaminants based on the surfaces that were sandblasted and the general cleanliness of the sandblast areas in the shipyards.

Historical and recent data analysis from shipyard sites in the Lower Duwamish River support the conclusion that spent sandblast grit can contain significant levels of PAH, along with other contaminants (McLaren Hart, 1992; Duwamish Shipyard Inc., 2011).

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Actual Comments from the Public from 2012

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October 10, 2012

Rebecca Hoff
NOAA Office of Response and Restoration
7600 Sand Point WayNE
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Re: Port of Seattle Comments on Draft Programmatic Restoration Plan & Programmatic Environmental Impact Statement

Dear Ms. Hoff:

The Port of Seattle is submitting the enclosed comments on NOAA's Supplement to the Draft Programmatic Restoration Plan & Programmatic Environmental Impact Statement (RP/PEIS) issued July 27, 2012. Included in our comments are analyses prepared by Windward Environmental on behalf of the Port and the Puget Sound Commerce Center, Inc. (formerly Todd Shipyards) concerning RP/PEIS Appendix C (Defining Injuries to Natural Resources in the Lower Duwamish River) and Appendix F (Allocation Process in the Lower Duwamish River Natural Resource Damage Assessment).

The Port is very concerned that NOAA has greatly overestimated damages to natural resources in the Lower Duwamish River and the Harbor Island Waterways by relying on unsupported assumptions and an overly simplistic approach to what must necessarily be a complex damage assessment analysis. The Port is also concerned with the approach to liability allocation used by NOAA, as described in Appendix F, that results in current shoreline property owners being assigned essentially all site NRD liability, including liability for activities that occurred in the distant past that current shoreline property owners had no role in, and liability for hazardous substance releases that clearly originated from other parties. This approach to damage assessment does not meet NOAA's burden of demonstrating that a party's natural resource damages debit "result[s] from" hazardous substance releases associated with that party. 42 U.S.C. 9607(a)(4)(C).

The result of the approach to damage assessment and the arbitrary allocation methodology documented in RP/PEIS Appendices C and F is that certain public and private entities are unjustifiably assigned vast amounts of natural resource damages liability, with other parties that have been responsible for significant releases apparently being assigned little or no such liability. Substantially overestimating natural resource damages, and then unfairly allocating the purported liability, has unfortunate consequences for both the environment and the current shoreline property owners along the Duwamish and Harbor Island Waterways. Without a reasonable and defensible damage assessment and liability allocation, parties assigned large shares of liability will be unwilling to enter into agreements to restore habitat and provide needed environmental improvements. Many Duwamish corridor parties, including the Port, are both willing and eager to participate in habitat restoration projects and to resolve issues associated with the natural resource damages for which they can legitimately be held liable. However, the approaches used by NOAA for damage assessment and liability allocation have stood as an impediment to moving forward for many years, resulting in very few substantial settlements.

As documented in the attached comments, NOAA should revisit its assessment of damages to take into account the mountain of new data and information that has been developed for the Duwamish and Harbor Island Waterways since the early- to mid-1990s. The Port and other parties have spent tens of millions of dollars in the characterization of the sediments at those sites and the evaluation of their potential impacts on human health and the environment. Rather than focusing on that wealth of new and more reliable information, NOAA has chosen for most hazardous substances to use screening levels taken from a more limited, and much older, dataset. NOAA has taken the screening levels calculated from that limited dataset and misapplied them based on the faulty assumption that those values represent the concentrations at which significant injuries to biota begin to occur. Instead, as explained in the Windward comments, the calculated screening levels are conservative values most appropriately used as thresholds for determining when damage to biota is *not* occurring due to a particular hazardous substance rather than values that show the onset of damage.

Further, for a limited set of substances, NOAA has rejected the screening values taken from the old dataset and used a small set of highly questionable studies to derive even lower thresholds for damages. The values derived by NOAA from those studies are inconsistent with the results of numerous other studies and with generally accepted reference toxicity values of the type used for the Duwamish and East Waterway Ecological Risk Assessments. For example, the PAH thresholds used in Appendix C were derived based on an assumption that the sampled fish had lifetime exposures to the concentrations ofPAHs found immediately adjacent to where the fish were caught. However, the highly mobile fish involved range over a larger area. When the same analysis is performed using average concentrations across a more realistic home range area, the threshold concentrations go up four fold.

NOAA's mistake in assuming that exposure indications for mobile species can be validly correlated to point concentrations of contaminants is compounded by the assumption that any indication of exposure, such as the presence of biomarkers, represents an actual injury. In reality, biomarkers and other exposure indicators are just that-mere indications that exposure has occurred and that the species in question has reacted to that exposure by, e.g., producing more of the enzyme needed to metabolize a certain compound. An indication of exposure is the first step in evaluating whether an effect may be present, not the last.

Finally, NOAA's damage assessment mistakes are compounded yet again by simply assuming that substantial service losses occur at the extraordinarily low concentrations where NOAA believes exposure indications begin to appear. Although scientific studies exist demonstrating actual harm at much higher concentrations, meaning service losses at those concentrations could validly be estimated, NOAA has assigned very significant service losses to concentrations far below those levels. By contrast, the Duwamish and East Waterway Ecological Risk Assessments, which were performed under the oversight of the U.S. Environmental Protection Agency and the Washington Department of Ecology, relied on more credible and accepted science and found relatively little ecological risk at these sites. The high hazardous substance concentrations that demonstrably result in meaningful effects on the species present in the Duwamish are simply not found at many locations, resulting in low ecological risk.

The unsupportable approaches to damage assessment and liability allocation presented in Appendices C and F demonstrate the need for NOAA to rework both its assessment of damages and its assignment of liability for those damages. This need not be a multi-year, multi-million dollar effort. A more streamlined, reasonable approach is possible using existing data and more defensible damage thresholds. Plumes can readily be defined based on the data that NOAA has to date chosen to ignore, and liability can proportionally be assigned to those parties that can clearly be shown to have caused significant releases of the hazardous substances involved.

Continuing to rely on an outdated and indefensible damage assessment and an arbitrary damages allocation will result in the continued waste of valuable public and private resources that could be better spent actually restoring habitat. The Port urges NOAA to apply a more reasoned approach to damage assessment and liability allocation. An approach of that type will avoid the situation where some parties are assigned huge amounts of liability, while other genuinely liable parties are assigned virtually none, or are ignored altogether. The "winners" in the game that NOAA is currently playing will, of course, consider moving forward with settlements, but little new habitat will be created because their assigned liability is minimal. The "losers" will not be willing to settle based on the damage assessment and liability allocation as it is currently structured, as their liability has been dramatically overestimated. The result is that the habitat that could have been created by settlements with those parties will have to wait, as it already has for the 20 years following NOAA's settlement with the City and County. NOAA should turn away from this lose/lose approach that has stymied habitat creation in the Duwamish for two decades and move forward with a more defensible, streamlined approach.

Thank you for considering the Port's comments. We would be happy to discuss the issues raised by our comments at any time.

Very truly yours,

S

Senior Port Counsel
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Enclosure

cc: Stephanie Jones Stebbins

VIGOR
INDUSTRIAL

October 10, 2012

Rebecca Hoff
NOAA Office of Response and Restoration
7600 Sand Point Way NE
Seattle, WA 98115

Re: Puget Sound Commerce Center, Inc. (f/k/a Todd Shipyards Corporation) Comments on Draft Programmatic Restoration Plan & Programmatic Environmental Impact Statement

Dear Ms. Hoff:

Puget Sound Commerce Center, Inc. (f/k/a Todd Shipyards Corporation) ("Todd") is submitting the enclosed comments on NOAA's Supplement to the Draft Programmatic Restoration Plan & Programmatic Environmental Impact Statement (RP/PEIS) issued July 27, 2012. Included in our comments are analyses prepared by Windward Environmental on behalf of the Port and Todd concerning RP/PEIS Appendix C (Defining Injuries to Natural Resources in the Lower Duwamish River) and Appendix F (Allocation Process in the Lower Duwamish River Natural Resource Damage Assessment).

Todd is concerned that NOAA has greatly overestimated damages to natural resources in the Lower Duwamish River and the Harbor Island Waterways by relying on questionable assumptions and a simplistic approach. As documented in the attached comments, we urge NOAA, in performing its assessment of damages, to utilize the extensive new data and information that has been developed for the Duwamish and Harbor Island Waterways since the early- to mid-1990s. NOAA's assumptions of significant service losses at extremely low concentrations is in direct contrast to the Duwamish and East Waterway Ecological Risk Assessments, which were performed under the oversight of the U.S. Environmental Protection Agency and the Washington Department of Ecology, which found relatively little ecological risk at these sites.

Todd believes that the assessment of damages and assignment of liability presented in Appendices C and F need to be revised. This need not be a multi-year, multi-million dollar effort. A more streamlined, reasonable approach is possible using existing data and more defensible damage thresholds.

Thank you for considering our comments. Please let me know if you would like to discuss our comments in more detail.

Very truly yours,

T. Alan Sprott

T. Alan Sprott
Vice President, Environmental Affairs

Enclosure

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MEMORANDUM

To: Jon Sloan, Port of Seattle, and Alan Sprott, Puget Sound Commerce Center, Inc. (fka Todd Pacific Shipyards)

From: Ron Gouguet and Susan McGroddy, Windward Environmental LLC

Subject: Review of Appendix C, Defining Injuries to Natural Resources in the Lower Duwamish River, in the *Draft Lower Duwamish River NRDA Programmatic Restoration Plan and Programmatic Environmental Impact Statement*

Date: October 9, 2012

The natural resource trustees (Trustees) for the Duwamish River published a draft update to their *Draft Lower Duwamish River NRDA Programmatic Restoration Plan and Programmatic Environmental Impact Statement* (NOAA and USFWS 2009). The document attempts to explain how the Trustees intend to adapt the damage assessment approach used to scale injury in the Hylebos Waterway to conduct a damage assessment for the Lower Duwamish River. We have reviewed Appendix C, Defining Injuries to Natural Resources in the Lower Duwamish River, and have the following comments.

In general, we believe that the analysis provided in Appendix C (NOAA and USFWS 2009) is inappropriately based entirely on literature toxicity values and state screening values, ignoring the extensive dataset associated with the Lower Duwamish Waterway (LDW) remedial investigation (RI), including sediment bioassay testing and tissue concentrations, and the assessment of ecological risk in the LDW ecological risk assessment (ERA). Furthermore, the use of literature toxicity values and sediment guidelines to calculate service loss rather than site-specific data results in an overly conservative assessment of injury. In many cases, the sediment concentration associated with a given service loss is associated with a threshold for the induction of biomarkers of organism exposure that are not causally linked to measurable effects on populations or communities that would constitute a service loss. For polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and tributyltin (TBT), service loss threshold concentrations have been identified based on a small number of studies that do not provide sufficient justification in support of the values used in Appendix C. Specific concerns regarding the values for each of these chemicals are identified below.

For chemicals other than PCBs, PAHs, and TBT, apparent effects threshold (AET) values are used to calculate service losses. This use of AETs is not consistent with their intended use as screening values that most accurately identify sediment for which no biological effects would be expected. The exceedance of an AET may or may not indicate the presence of biological effects. In the following sections, specific issues associated with the analysis presented in Appendix C (NOAA and USFWS 2009) are discussed, followed by an evaluation of AETs as predictors of biological effects conducted using sediment collected within the Lower Duwamish River.

Finally, there is no discussion provided in Appendix C (NOAA and USFWS 2009) to support the service loss percentages assigned to each threshold concentration. The lowest threshold concentration for every chemical is consistently associated with 5% service loss; and for all chemicals other than PAHs, PCBs, and dichlorodiphenyltrichloroethane (DDT) isomers, the highest threshold concentration is associated with a 20% service loss. The highest level of service loss for PAHs and PCBs was 80%; and for DDT isomers, the highest level of service loss was 40%. There is no explanation provided for the different levels of service loss assigned to different chemicals or to justify the levels of service loss associated with the threshold values for each chemical.

1 Injury Thresholds For PAHs, TBT and PCBs

For most chemicals, AETs are used in Appendix C (NOAA and USFWS 2009) as the basis for determining whether damage to natural resources from hazardous substance releases has occurred. However, injury thresholds for PAHs, TBT, PCB, and DDT isomers were not calculated based solely on Washington State AET values. For these chemicals, a combination of AETs and a small number of literature studies were used to establish injury thresholds. Very little detail is provided in Appendix C to support the threshold values that have been identified for these chemicals. In general, the selected values are well below the toxicity reference values used to evaluate these chemicals in the LDW RI; and for PAHs and PCBs, threshold values were established based on biomarkers of exposure that cannot be definitively associated with an effect that would result in a service loss.

1.1 PAH Injury Assessment

The two studies that were cited in Appendix C (NOAA and USFWS 2009) to support the assessment of injury to fish by PAHs in sediment are Johnson et al. (2002) and Rice et al. (2000). The values selected from these studies to assess injury to fish overpredict injury by assigning injury based on physiological indicators of exposure and reversible suborganismal effects.

The data underlying the effects thresholds overestimate the potential for adverse effects. The sediment effects thresholds for liver disease from Johnson et al. (2002) were biased low because all lesion types were assumed to cause disease in affected fish, whereas only a fraction of the lesion types were frank lesions indicative of disease. Furthermore, the co-located sediment and tissue data used to develop the hockey stick regression underestimated the PAH concentrations to which English sole were likely exposed prior to sampling. Stern et al. (2003) conducted a re-analysis of the hockey stick regression using the same lesion data as that used in Johnson et al. (2002) and a larger sediment dataset. Instead of using co-located sediment data from trawls, Stern et al. (2003) used spatially weighted average sediment PAH concentrations from the trawl area collected over realistic home range. This re-analysis resulted in an effects threshold for lesions that is four times higher than that presented in Johnson et al. (2002).

The sediment effects thresholds for reproductive dysfunction from Johnson et al. (2002) are highly uncertain. The statistical analysis relied on estimates of the background level of reproductive dysfunction and the inflection point (i.e., the concentration at which effects begin to be elevated above background) because insufficient data were available to calculate these parameters. In addition, as described above, for liver disease, the sediment concentrations to which English sole were exposed prior to sampling were likely to be underestimated. Furthermore, the causal relationship between observed reproductive effects and sediment PAH concentrations is unclear. For example, in one study (Casillas et al. 1991) that underlies the Johnson et al. (2002) relationship for gonadal growth, PAH concentrations accounted only for 34% of the variance in ovarian development, indicating that other factors may be causative. Differences in ovarian development could be due to natural variation in maturation timing among English sole subpopulations in Puget Sound or to exposure to other environmental stressors.

The sediment effect threshold for growth from Rice et al. (2000) is also uncertain. In this study, juvenile English sole were fed polychaete worms that had previously been exposed in the laboratory to 0.1% sediment from the Eagle Harbor, Washington, Superfund site mixed with 99.9% sediment from a reference site. PAH concentrations were reported for the sediment and worm tissue; other uncharacterized chemicals may also have been present but were not analyzed.[1] The major chemical contaminants present at Eagle Harbor were associated with creosote, which is used as a wood preservative. The major creosote-related chemicals generally associated with toxicity are PAHs, phenols, and cresols (ATSDR 2002). About 300 chemicals have been identified in coal tar creosote, but as many as 10,000 other chemicals may also be in this mixture (ATSDR 2002). Rice et al. (2000) showed that in one experimental trial, fish exposed to contaminated worms that contained a total PAH concentration of 11.3 parts per million (ppm) dry weight (dw) had a lower daily growth rate than did the controls. In a second trial of the experiment, a similar trend was observed, but the effect was not statistically significant.

There is no discussion in Appendix C (NOAA and USFWS 2009) of how the results of the toxicity studies (Johnson et al. (2002) and Rice et al. (2000) support the establishment

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[1] Concentrations were reported as low-molecular-weight PAHs (LPAHs) and HPAHs; the specific individual PAHs quantitated were not reported.

of 20 and 40% service losses for invertebrates and fish, respectively, at a total PAH concentration of 1 ppm in individual sediment samples. The exposure of highly motile organisms such as English sole is integrated over the entirety of their home range and cannot be evaluated on a point basis. The development of these thresholds has been shown to be highly sensitive to the sediment data selected as the exposure concentration. The assumption that a concentration at a point located proximate to the trawl line represents the lifetime exposure of a highly mobile fish is not logical. Furthermore, the 1-ppm concentration is associated with the presence of lesions that are reversible suborganismal effects. The consequences of such alterations in biochemical processes with regard to the health of the fish are largely unknown. They are not clearly linked to effects on populations or communities that constitute a measurable ecological service loss. It should also be noted that the 1 ppm total PAH concentration is much lower than the AET of 69 ppm for high-molecular-weight PAHs (HPAHs). Finally, PAHs were evaluated in the LDW ERA for potential risk to English sole; and based on an evaluation of the prey items collected throughout the LDW, no risk to English sole from exposure to PAH concentrations in the LDW was identified.

1.2 TBT Injury Assessment

The development of TBT injury threshold values is based on work that evaluated the effect of TBT on the marine polychaete *Armandia brevis* (Meador and Rice 2001) and bioaccumulation modeling based on relatively few datasets, including the *A. brevis* data (Meador et al. 2002). There is a significant amount of literature on the effects of TBT on benthic organisms that is not represented. The bioaccumulation potential for TBT has been shown to be highly species specific (Meador et al. 1997). Further justification should be provided to support setting injury thresholds based on a polychaete species that has not been observed in the Lower Duwamish River.

TBT was not identified as a risk driver in the ERA conducted for the LDW Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) evaluation based on the evaluation of imposex in benthic organisms collected throughout the site and the evaluation of chemical concentrations in tissue collected from throughout the site and compared with tissue effect concentrations. The data collected from the site is not consistent with the level of injury that would be predicted by the proposed injury threshold values.

1.3 PCB Injury Assessment

The assessment of service losses due to the exposure of benthos to PCBs is based on total PCB AET values. The assessment of injury to fish is based on work done by Meador et al. (2002) and NOAA (2001), which evaluate effects of PCB exposure on juvenile Chinook salmon. Meador et al. (2002) is cited as the source of the values used as thresholds for the 20 and 60% service losses. The relationships between sediment concentrations and adverse effects reported in Meador et al. (2002) rely on several assumptions that are highly uncertain. Meador et al. (2002) estimated organic carbon-normalized sediment effects thresholds from lipid-normalized PCB concentrations in salmon that were associated with various effects. In each of the 15 studies underlying this relationship, some data critical to the analysis (e.g., tissue PCB concentrations, tissue lipid concentrations) were not reported but were instead estimated based on uncertain assumptions. For example, in the study associated with the lowest effects threshold, Melancon and Lech (1983) reported increased levels of a biomarker of chemical exposure (hepatic mono-oxygenase activity [ethoxyresorufin-O-deethylase (EROD)]) in juvenile rainbow trout associated with the injection of PCBs into their body cavity. Melancon and Lech (1983) did not report the tissue concentration of PCBs in the trout, so Meador et al. (2002) assumed that 75% of the injected dose was absorbed into the tissue. In addition, Melancon and Lech (1983) did not report the lipid content of the trout so Meador et al. assumed 9% lipid based on estimates for adult fish. Based on these assumptions, Meador et al. (2002) calculated a PCB tissue residue of 1.7 µg/g lipid as the effect threshold. A later report by the authors of the original study (Melancon et al. 1989) suggested that such effects occur at a muscle concentration of approximately 0.3 µg/g wet weight (ww), which, using the assumptions from Meador et al. (2002), would correspond to 3.3 µg/g lipid. Similar assumptions made for the other 14 studies are more likely to underestimate rather than overestimate the tissue concentration at which the effect is likely to occur. Consequently, the sediment effects thresholds are more likely to underestimate than overestimate realistic effect thresholds and result in an overprediction of injury.

Furthermore, as is the case for PAHs, many of the effects included in Meador et al. (2002) are physiological indicators of exposure and reversible suborganismal effects. Examples included altered levels of hormones, changes in enzyme activity, or decreases in the synthensis of vitellogenin (a precursor protein of egg yolks). The effects associated with a 60% service loss from NOAA (2001) are also biomarkers (i.e., immune suppression and cytochrome P450 induction). The consequences of such alterations in biochemical processes with regard to the health of the fish are largely unknown.

2.0 Use of AETs in Injury Assessment

For all chemicals other than PAHs, TBT, PCBs, and DDT congeners, Washington State AETs were used to identify threshold concentrations for service losses. AET values were developed as screening concentrations and are inherently conservative values that will overestimate biological effects. In the following sections, the development of AETs is described, and the use of AETs in the Hylebos Model is examined. Finally, the predictive power of AETs is tested with a dataset that includes sediment chemical concentrations and bioassay results from the LDW and East Waterway (EW).

2.1 Development of Apparent Effects Thresholds

In Washington State, AETs have been developed for several biological endpoints, including field measures of benthic infaunal abundance, results of laboratory toxicity tests using marine benthic invertebrate organisms (i.e., amphipods [survival] and oysters [percent abnormal development of oyster larvae]), and results of laboratory toxicity tests using bacteria (Microtox® [decreases in luminescence from the bacteria *Vibrio fisheri*]). For each hazardous substance, the AET is the chemical concentration in sediment above which statistically significant biological effects are always expected for one or more biological effects indicators.

The sediment used in the development of AETs contained a variety of chemicals with a range of concentrations. These complex mixtures present issues when interpreting the cause of any observed biological effects because it is difficult to identify the chemical or chemicals that are responsible for the biological effects or toxicity. If, for example, a particular chemical consistently co-occurred with a more toxic chemical in sediment sampled for the calculation of AETs, the AET value for the less toxic chemical could be much lower than the "true" toxic threshold for the chemical based on exposure to the chemical alone.

In addition to the complexity of the chemical mixture, other confounding factors that can affect the bioassay result are geochemical (e.g., organic carbon, sulfides, ammonia) and physical properties (e.g., grain size, porosity) of the sediment. These confounding factors can result in significant organism mortality, or other observed effects, resulting in the attribution of effects to chemical concentrations that are not causing the effects. Because effects associated with co-occurring chemical and other confounding factors are not taken into account when AETs are calculated using field sediment. AETs are inherently conservative values and are most useful as screening benchmarks. There is no basis for using AET values as the threshold concentrations at which a particular hazardous substance causes damage to natural resources because AETs do not establish a causal relationship between biological effects and a chemical of concern.

The Washington State Sediment Management Standards (SMS) recognize the uncertainty associated with the use of the AET values and allow for the use of sediment bioassay results as the direct measure of the biological effects to supersede the chemical exceedances of AET thresholds in the characterization of sediment. The SMS use AET values as a screening tool that can be superseded by bioassay results, which provide a direct measurement of sediment toxicity and are recognized as a more reliable predictor of sediment quality.

2.2 Use of AETs in the Hylebos Model

AET values in conjunction with the Hylebos Model are used to predict benthic effects presented in Appendix C (NOAA and USFWS 2009). Sediment with a chemical concentration above an AET value is assigned a specific level of injury. As an example, the "injury ramp" for butyl benzyl phthalate (BBP) is presented in Table 1. No effort was made to evaluate the available sediment bioassay data for the Lower Duwamish River to determine the relevance of the AET thresholds for the mixture of contaminants at these sites. Increasing levels of injury are assigned based on the exceedance of multiple AET values. No justification is provided for increasing service loss percentages when multiple AET values are exceeded.

Table 1. Hylebos/Commencement Bay damage assessment injury ramp for butyl benzyl phthalate

Endpoint	AET	% Service Loss
Microtox	63	5
Bivalve	100	na
Echinoderm	200	10
Oyster	> 470	na
Neanthes	> 580	na
Benthic community	900	15
Amphipod	970	20

Source: Table C-5 of Appendix C (2009)
AET – apparent effects concentration
na – not available

For many of the chemicals discussed in Appendix C (NOAA and USFWS 2009), the AET values that are used to represent different levels of injury are not analytically distinct concentrations. For example, in Table 1, a butyl benzyl phthalate sediment concentration of 900 µg/kg is associated with a 15% service loss, and a sediment concentration of 970 µg/kg is associated with a 20% service loss. The standard allowable analytical precision for the measurement of butyl benzyl phthalate in sediment is ± 50% of the measured concentration. The difference between the two AET values is less than 10% and is well within the allowable analytical precision for this chemical, which means that the duplicate analysis of a sediment sample that yielded 900 and 970 µg/kg would represent acceptable accuracy for the analysis. Other chemicals for which there are AETs associated with variable injury levels that are clearly within the analytical precision of the measurements are 1,2-dichlorobenzene, 1,4-dichlorobenzene, 1,2,4-trichlorobenzene, cadmium, lead, mercury, silver, bis(2-ethylhexyl) phthalate, and dimethylphthalate.

2.3 Case Study: Evaluation of Effects Predicted by AETs Compared with Effects Measured in LDW and EW Sediment

In order to evaluate the predictive power of AETs in the Lower Duwamish River, a dataset of 101 sediment samples collected from the LDW and East Waterway (EW) of Harbor Island was evaluated. All of these samples were submitted for chemical analysis and sediment bioassays for the LDW or EW CERCLA remedial investigations. The reliability of the chemical concentrations above the AETs as indicators of biological effects, as measured by the sediment bioassays, was evaluated.

For the purpose of this evaluation, the degree of chemical or bioassay exceedance was not considered; the only consideration was whether or not the chemistry and bioassay results exceeded the AET threshold for chemistry or the sediment quality standards (SQS) threshold for the bioassay results.

However, for the 95 samples that exceeded at least one of the AET values, the exceedance of the AET did not necessarily accurately predict the biological effects associated with the bioassay results. In 54% of these samples, the chemical exceedance of the AET was consistent with a bioassay result, which also exceeded the SQS threshold. However, in 46% of the samples, no toxicity was observed in the three sediment bioassay results for the sample. For this dataset, the AETs have functioned as intended, as a conservative screening tool with a strong tendency to overpredict toxicity in order to ensure that sediment classified as non-toxic on the basis of the chemistry results were reliably confirmed as non-toxic by the bioassay results.

These results suggest that the exceedance of an AET value should not be used as a reliable indicator of certain biological effects. AETs may function well as screening levels, but they are clearly not a reliable indicator of biological effect as demonstrated by the LDW and EW sediment bioassay results.

Finally, the LDW data was examined to determine whether the exceedance of multiple AETs increased the predictive power of the AET evaluation. The sediment concentrations in the LDW sediment were compared with six AET values. Of the 95 samples that exceeded at least one AET value, 48 samples exceeded 1 to 3 AET values, and 47 samples exceeded 4 to 6 AET values. Of the 48 samples that exceeded 1 to 3 AET values, 24 samples (50%) showed that there were no significant biological effects associated with the sediment bioassays. Of the 47 samples that exceeded 4 to 6 AET values, 20 samples (42%) showed that there were no significant biological effect associated with the sediment bioassays. This analysis would suggest that predictive power of the AETs is not improved when multiple AET exceedances are present. These results further suggest that it is not accurate to ascribe a greater level of effect or injury on the basis of the number of AET values exceeded.

In conclusion, our analysis of LDW sediment data does not support the assessment of benthic injury provided in Appendix C of the programmatic environmental impact statement (PEIS) (NOAA and USFWS 2009). Specifically, the exceedance of an AET value does not appear to predict benthic effects as represented by sediment bioassays undertaken using the same sediment to which the Appendix C evaluations were applied. Half of the sediment samples that exceeded at least one AET value did not exhibit significant biological effects in the sediment bioassays. Finally, it was determined that the exceedance of multiple AET values did not appear to improve the predictive power of the AET analysis and do not support the idea that the exceedance of greater numbers of AETs represents a greater injury or service loss as presented in Appendix C.

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MEMORANDUM

To: Jon Sloan, Port of Seattle, and Alan Sprott, Puget Sound Commerce Center, Inc. (fka Todd Pacific Shipyards)

From: Ron Gouguet and Susan McGroddy, Windward Environmental LLC

Subject: Review of Appendix F, Allocation Process in the Lower Duwamish River Natural Resource Damage Assessment, in the *Draft Lower Duwamish River NRDA Programmatic Restoration Plan and Programmatic Environmental Impact Statement*

Date: October 9, 2012

The natural resource trustees (Trustees) have developed a set of highly conservative screening-level assessment tools to help the Trustees provide an opportunity for early settlement of claims for alleged natural resource damages in the Lower Duwamish River. This is the step in the process where the total service losses estimated by the Trustees are apportioned to a subset of the parties that contributed contamination, as identified by the Trustees. We reviewed Appendix F, Allocation Process in the Lower Duwamish River Natural Resource Damage Assessment, in the *Draft Lower Duwamish River NRDA Programmatic Restoration Plan and Programmatic Environmental Impact Statement* (NOAA and USFWS 2009) and have the following comments.

GENERAL COMMENTS

- The text provided in Appendix F (NOAA and USFWS 2009) is very general, with virtually no information specific to the Lower Duwamish River, which does not allow for a thorough review of the proposed Lower Duwamish River allocation.
- The approach does not adequately consider sources within the pipeshed for storm or combined overflows; and although the Trustees say that this was accounted for in the pipe discharges, the characterization of the chemical loads used for this purpose was not provided. The document fails to address parcels that do not abut the Lower Duwamish River but are associated with current and historical activities that may have resulted in the release of contaminants in to the Lower Duwamish River.
- The mass balance approach used for polycyclic aromatic hydrocarbons (PAHs) is not fully explained in this document. The information that has been provided on

the calculation of PAH release rates for marine pilings suggests that the release of PAH from creosoted marine pilings has been greatly overestimated.

- The association of PAHs with sandblast grit is inaccurate and results in an inappropriate assignment of discounted service acre years (dSAYs) to non-contributing parcels.

ALLOCATION BY UNIQUE FOOTPRINT

The Trustees applied the gradient analysis technique to provide an indication of the locations of sources potentially responsible for a portion of the contaminants in sediment. This technique assumes that maximum concentrations occur near sources and decline with distance. Appendix F, Figure F1 (NOAA and USFWS 2009), is a hypothetical injury footprint showing a gradient of contamination emanating from a land-based source with a resulting sediment plume.

In cases where a plume that originates at one parcel overlaps onto adjacent parcels, liability has been allocated to multiple parcels rather than to the single parcel that is the likely source. In cases where sufficient information is available to identify the unique sources, the Trustees should allocate liability to the specific source rather than simply allocating liability to all adjacent properties.

Additional information, such as co-occurrence of chemicals, grain size, bathymetry, and historical marine development, can allow for a better understanding of a plume and assist in the assignment of responsibility for portions of a plume. More-sophisticated fingerprinting methods could be used to develop source signatures for unique plumes and could assist in a more rigorous allocation process. In general, the process provided here is overly simplistic and does not take advantage of the extensive chemistry dataset and current and historical source control documentation that is available for use in the allocation model.

ALLOCATION BY MASS LOADING

One substance of concern (SOC) (i.e., PAH) was allocated solely through the use of the mass loading approach because the contaminant concentrations were widely diffused throughout the Lower Duwamish River. Concentration gradients were discernible, but footprints were not readily definable. Thus, allocation to each site within the entire Lower Duwamish River was determined through mass loading, taking into account various sources of PAH to the Lower Duwamish River.

PAH MASS BALANCE ALLOCATION APPROACH

The Trustees chose to use a so-called “mass balance” approach to the allocation of PAH (the major injury driver in the Lower Duwamish River) as a substitute for the site-specific footprint approach used for all other chemicals. The details of the mass balance calculations conducted for PAHs are not provided in Appendix F. There is insufficient information provided Appendix F (NOAA and USFWS 2009) to justify the use of an alternative allocation approach for this important class of chemicals.

The use of the mass balance approach has resulted in a gross overestimation of the contribution of PAHs from marine pilings. In discussions with the Trustees, we have learned that the leaching rate used to characterize the loss of PAHs from marine pilings was 23%, which is the rate calculated by Valle et al. (2007) based on the release of PAHs from pilings into the water column. This rate is based on work by Ingram et al. (1982) and Bestari et al. (1998). In their work, the authors provided empirical observations on variables that control the rate at which PAHs leach from creosoted pilings, including the fact that PAH release rates are higher at higher temperatures, and PAH release rates in fresh water are twice the release rates in marine water. Although these uncertainties were noted by Valle et al. (2007) and Ecology (2012), they were not taken into account when site-specific release rates were calculated. Instead, Ecology (2012) and Valle et al. (2007) used a release rate based on freshwater releases at elevated temperatures to characterize the contribution of PAHs from pilings in the colder, marine waters of Puget Sound and other marine water of Washington State (Ecology and WDOH 2012). Based on the controlling factors identified by Ingram et al. (1982) and Bestari et al. (1998), a reliance on release rates obtained from warm fresh water greatly overestimates the contribution from creosote pilings to the waters in Washington State, including the Lower Duwamish River. The primary uncertainties associated with the PAH leaching rate are:

- The desorption rate is based on freshwater exposure. Results by Ingram et al. (1982) indicated that PAH release rates in salt water are half the rates reported in Bestari et al. (1998).
- The desorption rate of PAHs from pilings has been shown to be strongly temperature dependent. The laboratory experiments carried out by Ingram et al. (1982) were conducted at temperatures ranging from 20 to 40 °C, and the mesocosm experiments carried out by Bestari et al. (1998) were conducted outdoors in August with a water depth of 1 m. The temperature data were not reported, but the shallow water depth likely involved temperatures that were higher than the cooler water temperatures found in Puget Sound and other Washington State marine waters. Based on the analysis of temperature presented in Xiao et al. (2002), it appears that the PAH release rate at 20 °C is approximately twice the PAH release rate at 10 °C.
- The leaching of PAHs was observed only at the surface (1 mm) of the treated piling; no loss was observed from the deeper regions of the piling (Bestari et al. 1998). Therefore, only a small volume of creosote is available to function as a source of PAHs due to leaching.
- PAH desorption rates decline exponentially following the placement of freshly treated wood. The rate calculated by Bestari et al. (1998) was based on the

placement of treated wood in a mesocosm for 84 days, during which an exponential decline in PAH releases was measured.

> "In this study, total water column PAHs increased steadily to a maximum concentration at 7 d post-treatment, followed by an exponential decline to approximately background levels by 84 d" (Bestari et al. 1998).

The application of this rate to the 30-year lifespan of a piling is not supported by the research because it does not account for the fact that significant releases of PAHs only occur following the installation of the piling.

- Other important variables that have been shown to affect the release of PAHs but have not been accounted for in this analysis include creosote composition, the type of wood, the method of creosote application, water temperature, and flow rates.

It is our understanding that the rate of PAH release from marine pilings into the water column was applied to the portion of the marine piling in the sediment in order to estimate the contribution of the piling to the sediment PAH concentration. The many reasons why the rate of PAH release derived by Valle et al. (2007) is an overestimation of the release of PAHs from the pilings into the water column in Puget Sound waters are provided above. If this rate was applied to the portion of the piling buried in the sediment, then the release of PAHs from pilings has been greatly overestimated. There is no reason to assume that the rate of PAH release in the water column represents the rate of PAH release in the sediment. The physical and chemical properties of PAHs suggest that there is a strong thermodynamic tendency for PAHs to remain associated with the hydrophobic organic matrix of the creosote. Furthermore, there is no viable transport mechanism to move PAHs released into sediment 10 to 40 ft below the sediment surface upward into the biologically active zone where there is a potential for biological uptake.

IMPACTS ASSOCIATED WITH PAH LEACHING FROM PILINGS

Numerous studies have been conducted in an effort to quantify the effects of PAHs released from creosote-treated pilings in terms of increased PAH concentrations in the water column, sediment, and biota in the vicinity of these pilings. The conclusions of a variety of studies are summarized below. Very few impacts have been observed in the immediate vicinity of the pilings during the time period that immediately follows the placement of the pilings.

Ingram et al. (1982) conducted laboratory desorption experiments and concluded that:

> "The amount of creosote that migrates from creosote-treated marine piling is extremely small…. This small annual loss, plus the fact that PAHs apparently are rapidly broken down in sea water, indicates that the PAHs

> that migrate from creosote piling should have a negligible effect on the environment."

Bestari et al. (1998) conducted mesocosm studies in which changes in water column and sediment PAH concentrations were monitored over a period of months and concluded that there were no significant impacts from the leaching of PAHs in creosote from pilings:

> "The loss of PAHs from the water was not reflected as an increase in the sediments although an increase in PVC-bound PAHs was observed. Thus, it appears that the majority of PAHs leached into the water from the pilings is lost via natural physical (volatility, photodegradation) and biological (microbial degradation) pathways. In this sense, environmental impacts associated with loss of creosote from impregnated wood structures are most likely to occur during the initial periods following their placement in aquatic environments. Further, relatively low concentrations were recorded in this study so any impacts that do occur may be chronic, rather than acute, in nature."

A long-term *in situ* study carried out by Goyette and Brooks (1998) was conducted in Sooke Bay on Vancouver Island, British Columbia, Canada. This study is particularly relevant to Washington State marine waters because of the similarity in the conditions of exposure. This study included the placement of creosoted pilings and 4 years of monitoring of the chemical and biological impacts of the pilings. According to Goyette and Brooks (1998):

> "This study has shown that under worst case conditions, significant PAH contamination was restricted to an area within 7.5 meters from the perimeter of a significant structure. The response of an extensive infaunal community analysis and laboratory bioassays indicates that significant adverse biological effects were found within a distance of approximately 0.65 meters from the perimeter of the structure. Slight adverse effects were observed to a distance of 2.0m."

Finally, the Stratus report prepared for NOAA (Stratus 2006) is a compilation and critical review of the available literature that describes the release of PAHs from creosote-treated wood structures. The authors concluded that the impacts associated with PAHs released from pilings are likely to be small in both temporal and spatial scales.

> "Overall, the laboratory and field studies described above indicate that treated wood structures can leach PAHs and other toxic compounds into the environment. However, the degree of PAH accumulation to sediment associated with these structures appears to be relatively minor in many settings, particularly in well-circulated waters and over time. PAH accumulation also appears to be relatively limited spatially (within approximately 10 m of the structure) and has not generally been

> associated with measured, significant, biological effects except in close proximity to the structures. The duration of any biological effects also appears to become attenuated within several months of construction (the time period when leaching rates are likely to be highest)."

The conclusions of these studies would suggest that the injury resulting from the release of PAHs from pilings should not be large. However, it is our understanding from discussions with the Trustees that the preponderance of the PAH injury has, in fact, been allocated to releases from marine pilings.

Association of PAHs with Sandblast Grit

In addition, the Trustees have asserted that PAHs are associated with sandblast grit. This assertion has not been supported and is inappropriate. At a February 16, 2012, Trustee presentation regarding the natural resource damage assessment, the Elliot Bay Trustee Council listed "sandblasting grit" as a site-specific activity related to PAHs, along with asphalt production, creosote pilings, and vehicle washing. The Trustees stated that using their methodology, sandblast grit is associated with 18% of the total mass of PAHs released. However, the rationale for associating PAHs with sandblast grit is not known.

Metals and tributyltin are the primary chemicals associated with sandblast (also known as abrasive grit blast [AGB]). For the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sediment remediation project implemented at Todd Pacific Shipyards (now known as Puget Sound Commerce Center, Inc.), constituents of AGB were analyzed, and a definition of AGB in sediment was prepared and approved by the US Environmental Protection Agency (EPA). Copper, arsenic, and zinc, as well as grain size, were considered diagnostic of AGB, not PAHs. These metals plus grain size and/or a visual assessment allowed for the identification of AGB. PAHs were never associated with AGB nor used to identify AGB releases to the sediment.

In addition, as part of the source control work required by EPA for the CERCLA process at Todd Pacific Shipyards, the historical use and constituents of sandblast grit were evaluated. Kleen Blast, a vitreous copper smelter slag grit, and Tuf-Kut and Green Diamond, nickel slag grits, were evaluated. Kleen Blast grit contains moderate to trace levels of copper, lead, arsenic, and zinc, with copper occurring in highest concentration. PAHs are not constituents present in sandblast grit, and the manufacturers do not analyze for PAHs. Based on the above information, the correlation between sandblast grit and PAHs is inaccurate and should be removed.

Unallocated Footprints

The hypothetical example that illustrates the process described in Appendix F (NOAA and USFWS 2009) is not useful. It provides percent allocation figures as if there were a precise basis for them and explains the arithmetic of the calculation.

It is not clear why the Trustees included Table F3, activity ratings for polychlorinated biphenyls (PCBs) in Appendix F (NOAA and USFWS 2009). The explanation provided in Appendix F follows:

> "This table is intended to represent an initial screening of the relative ranking of activities with respect to their potential to release PCBs. Thus, all other things being equal (e.g., size, duration, degree of case, fate and transport, chemical concentrations) an **activity near the top of the list is expected to result in the release of a greater mass of SOCs than an activity near the bottom of the list. However, where things are not equal the actual mass contribution could be much different than that implied by the order noted in the table**."

The bold text is confusing and does not provide a clear explanation as to how this information was used in the allocation process.

CONCLUSIONS

The screening exercise described in Appendix F (NOAA and USFWS 2009) provides a brief and cursory description of the process that has been used to determine who is likely responsible for hazardous substance contamination and resulting injury in the Lower Duwamish River. The description of the approach employed by the Trustees does not provide enough information to allow for a full evaluation of the decision process that has been developed for this site.

The Trustees state that "The allocation process requires the use of professional judgment, largely to address variability in the amount, type and quality of data available for each site." The professional judgment that has been used for this site has not been sufficiently described in Appendix F. Furthermore, the results of the allocation process must be released in order to allow for a full understanding of the implications of the allocation process.

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